Driving Innovation through Life Cycle Thinking

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The Dow Chemical Company

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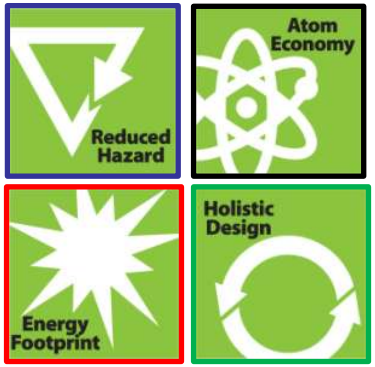
Impact equation

$$I = P * A * T$$

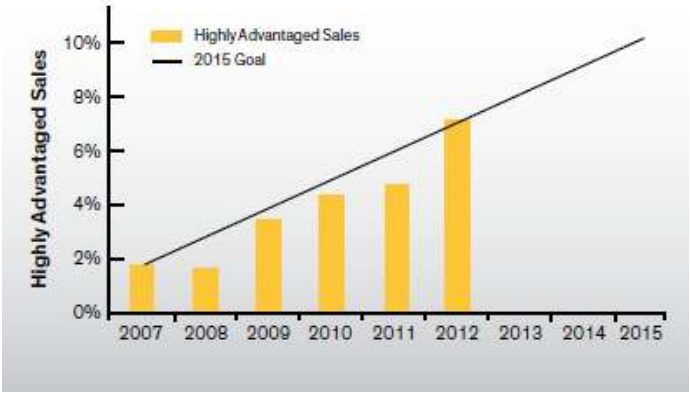
Our Definition of Sustainability

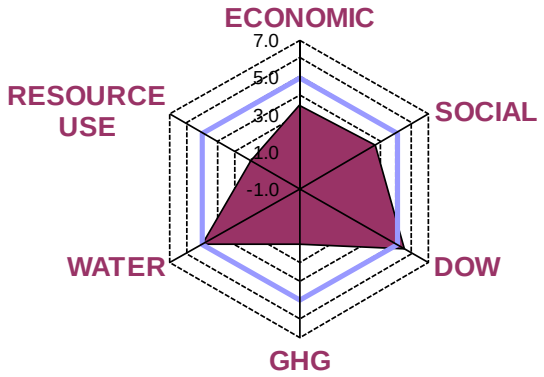
- **Sustainability** requires making every decision with the future in mind.
- It is our relationship with the world around us – creating economic prosperity and social value while contributing to the protection of our planet.

Ways to bring in life-cycle thinking

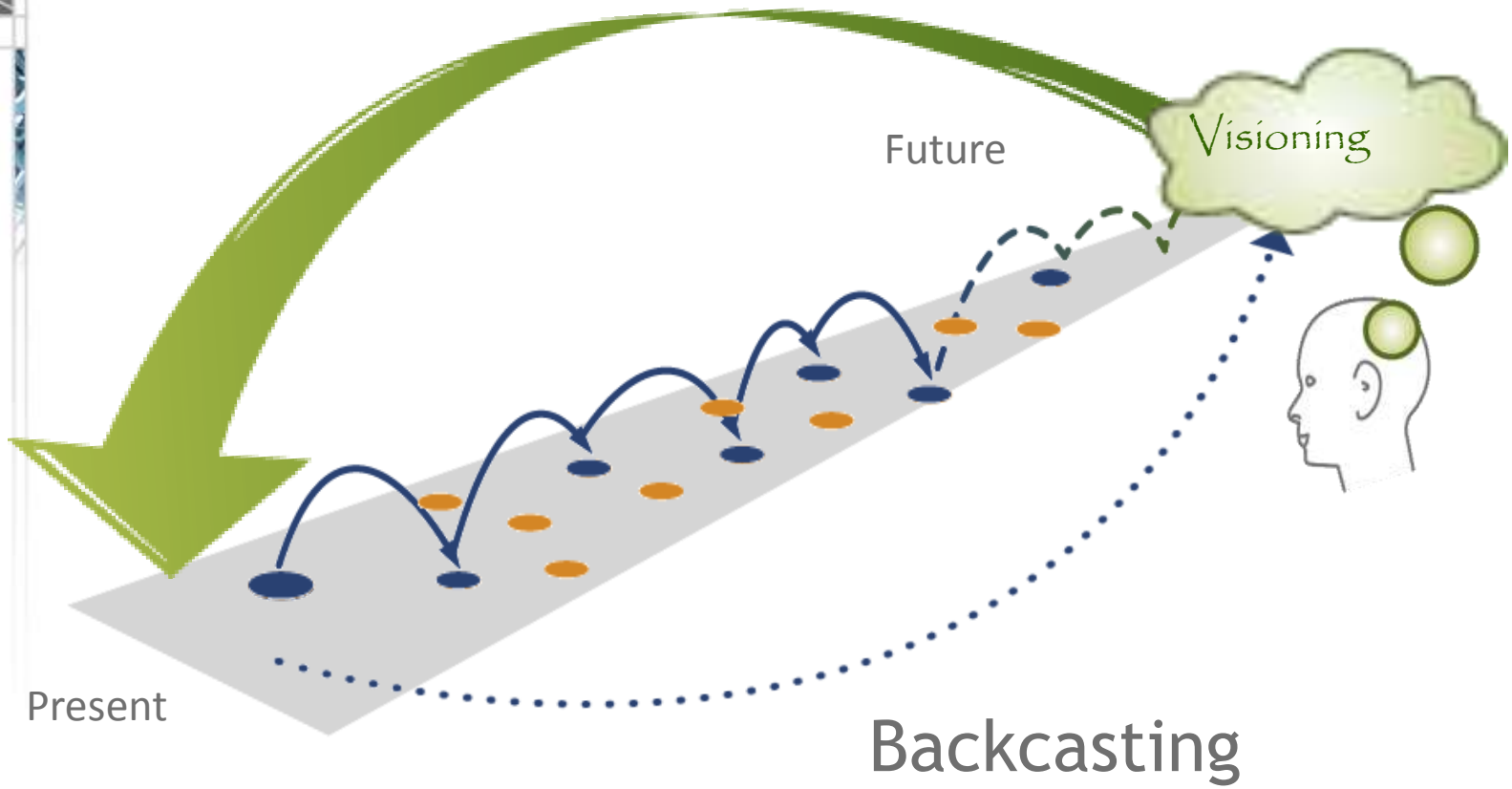


Life cycle assessment





Plan with a Sustainable Future in Mind



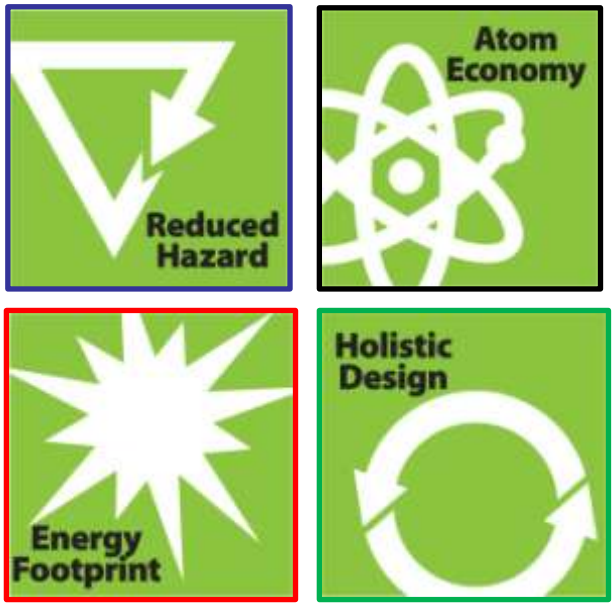
Source: The Natural Step

Dow's 2015 Sustainability Goals

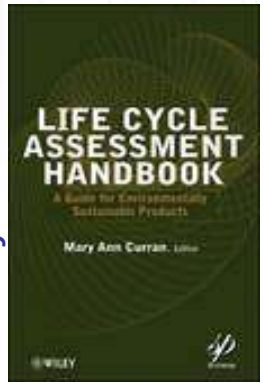
http://www.dow.com/sustainability/commit.htm

Principles of Green Chemistry & Engineering

Dow's "Principles of Sustainable Chemistry & Engineering" Program

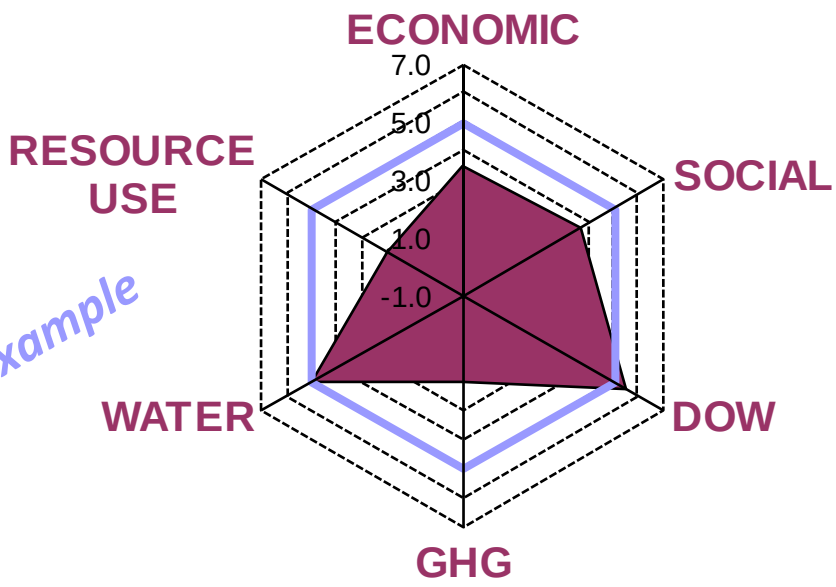


As found in



Dow Chemical Sustainability Footprint Tool©

23 questions compiled into 6 dimensions:



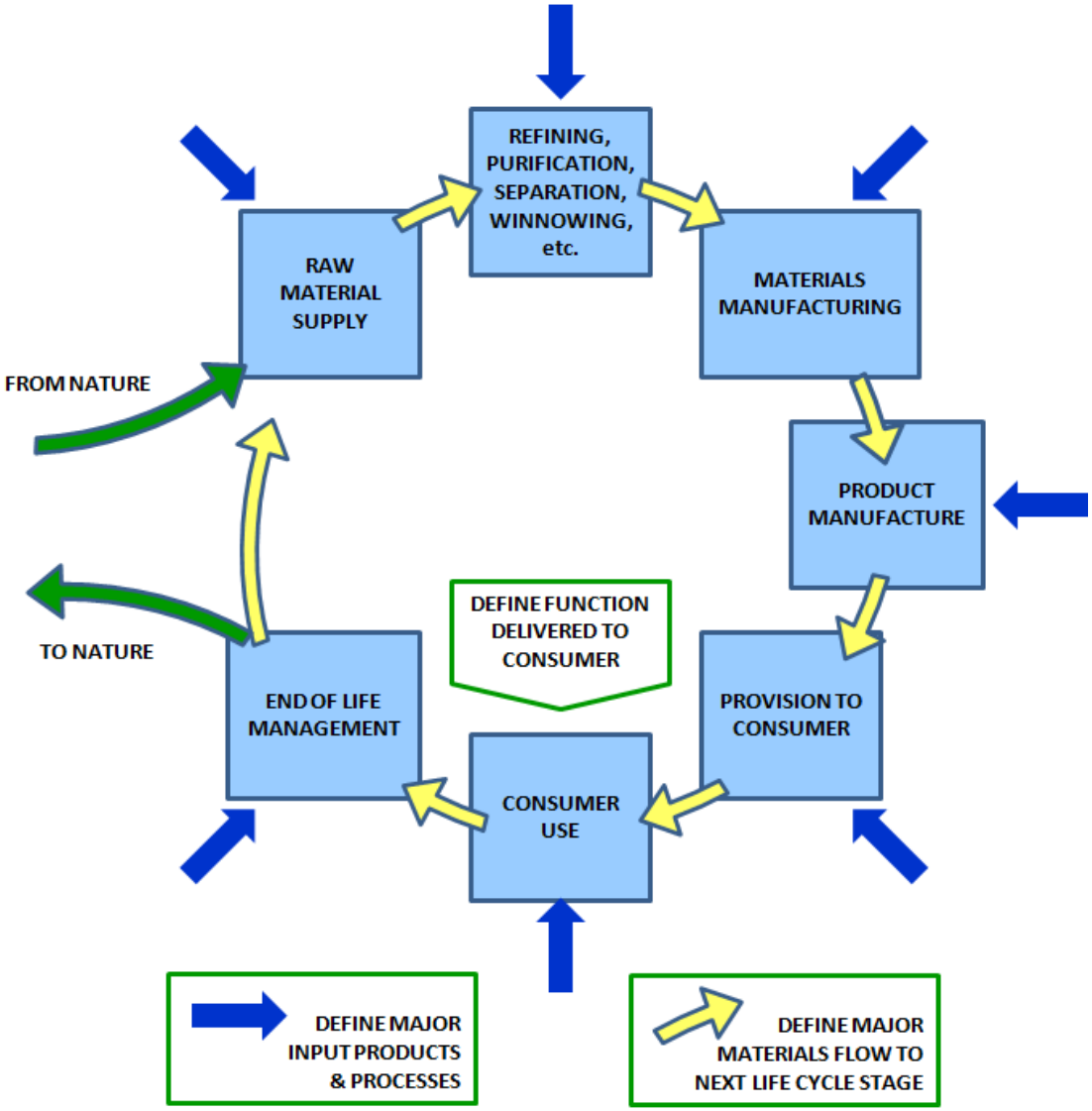
hypothetical example

Base Case:

Project relative footprint (smaller is better):

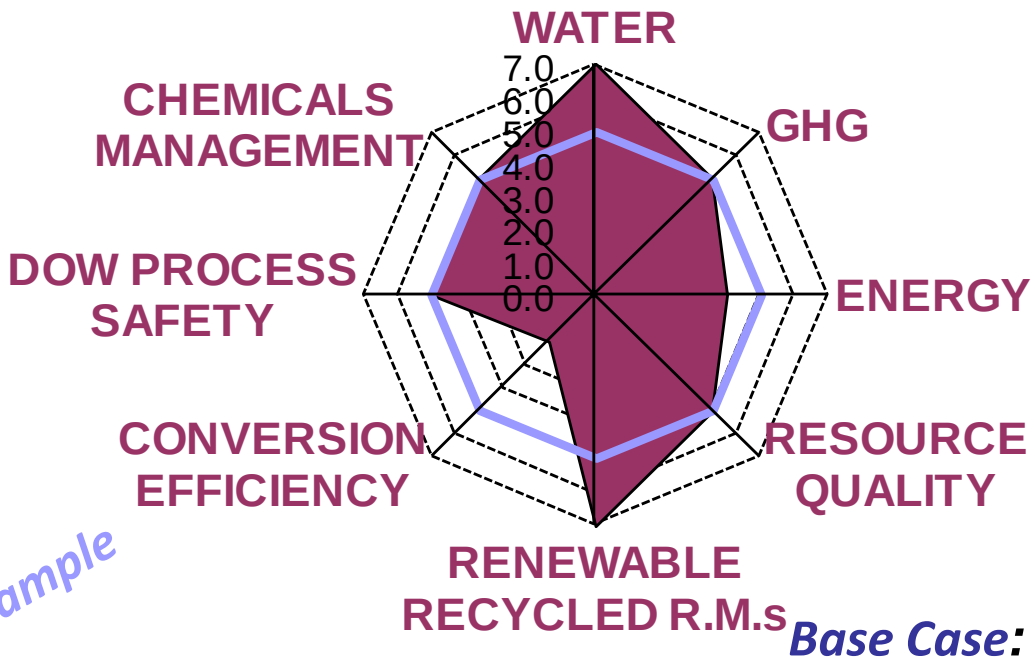
David A. Russell & Dawn L. Shiang.
ACS Sustainable Chem. Eng., **2013**, *1* (1), pp 2–7
http://pubs.acs.org/doi/abs/10.1021/sc300131e

Start with a flow diagram



The “Dow” dimension the Tool

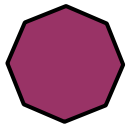
The Dow dimension considers 8 aspects:



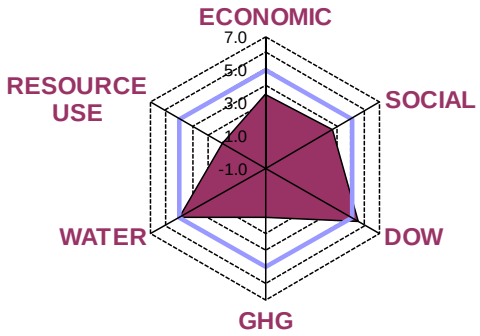
hypothetical example

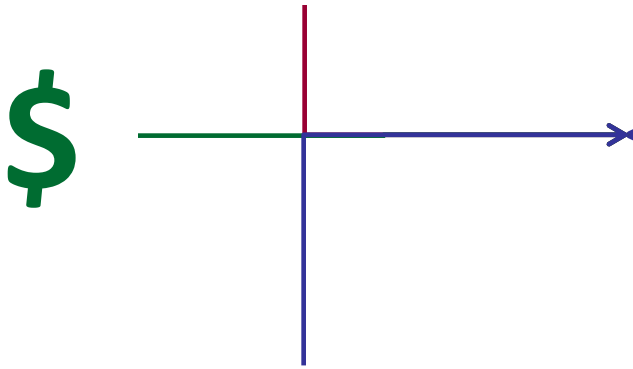
Base Case:

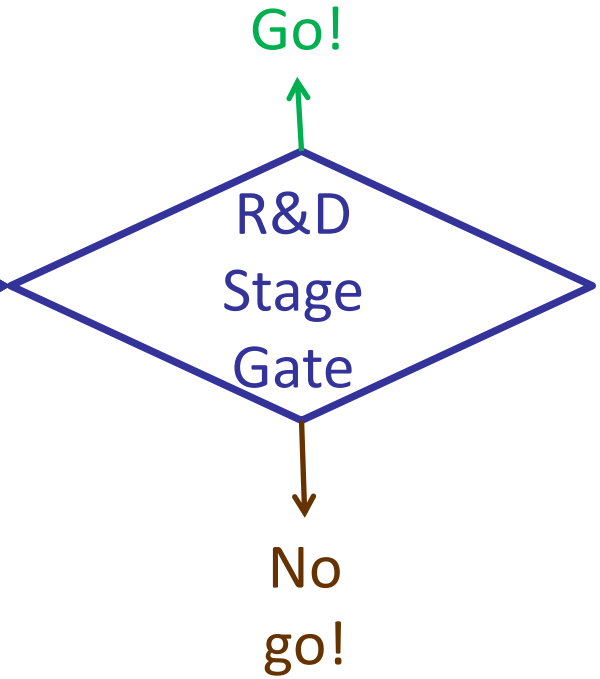
Project relative footprint (smaller is better):



Use of tool in R&D decisions







United States Patent [19]
Helling et al.

[11] Patent Number: 4,939,263
[45] Date of Patent: Jul. 3, 1990

[54] CONTROL OF ISOMER DISTRIBUTION IN A CHLORINATION PROCESS

[75] Inventors: Richard K. Helling, Martinez; Philip D. Grover, Concord; Thomas J. Dietsche, Berkeley; Mark L. Garbold, Martinez, all of Calif.

[73] Assignee: The Dow Chemical Company, Midland, Mich.

[21] Appl. No.: 413,926

[22] Filed: Sep. 28, 1989

[51] Int. Cl.[5] C07D 213/61
[52] U.S. Cl. 546/345
[58] Field of Search 546/345

[56] References Cited
U.S. PATENT DOCUMENTS

3,418,323 12/1968 Johnson et al. 546/345
3,721,220 3/1973 Brewer et al. 546/345
4,237,301 10/1980 Dietsche et al. 546/345
4,256,894 3/1980 Dietsche et al. 546/345
4,487,935 12/1984 Marinak et al. 546/345
4,556,681 1/1986 Marinak et al. 546/345
4,777,827 3/1988 Marinak et al. 546/345
4,901,532 10/1987 Humphreys et al. 546/345

Primary Examiner—Richard A. Schwartz
Assistant Examiner—J. Hagey
Attorney, Agent, or Firm—D. Wendell Osborne

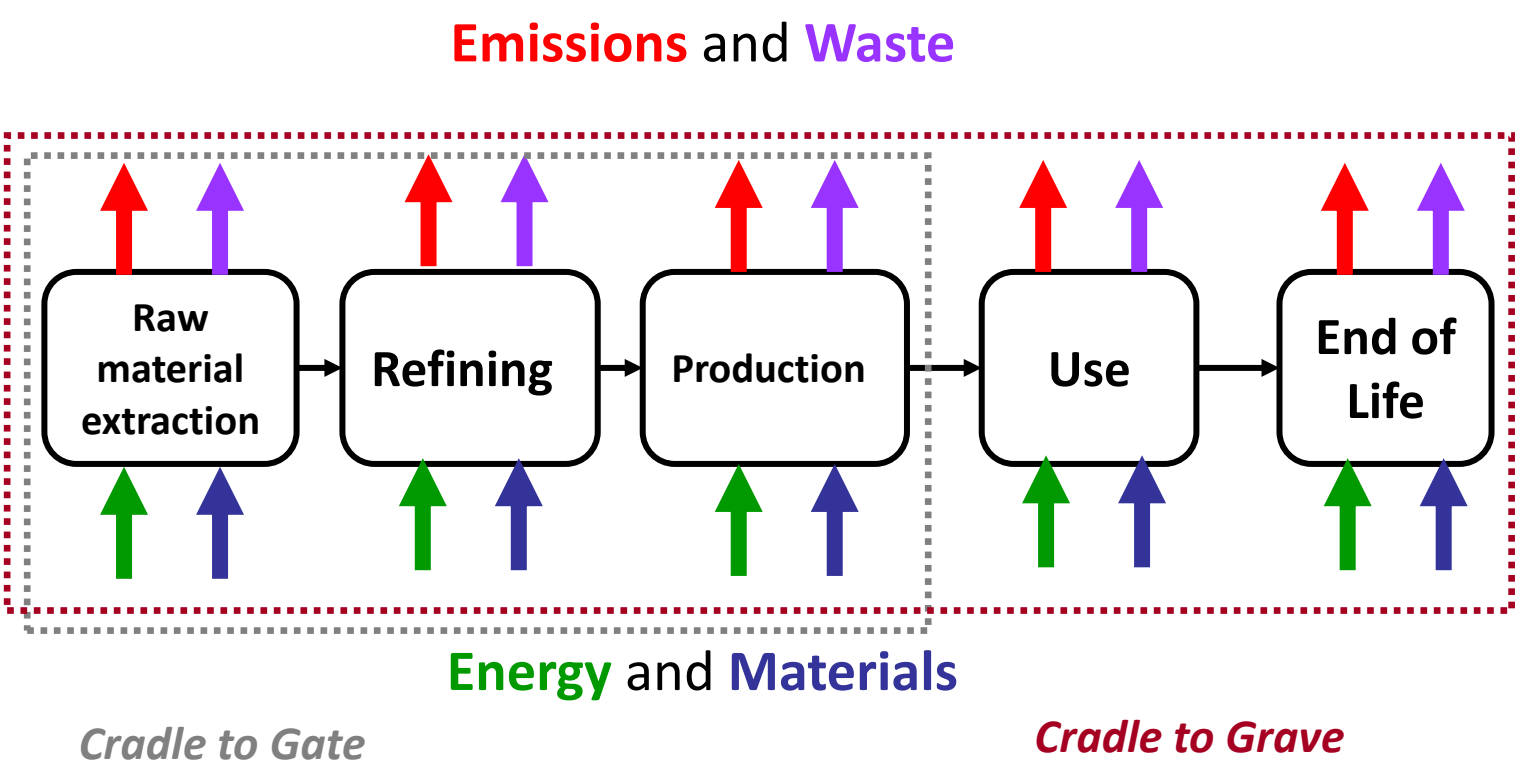
[57] ABSTRACT

The relative amounts of 3,6-dichloro-2-(trichloromethyl)pyridine and 3,5-dichloro-2-(trichloromethyl)pyridine obtained in the chlorination of 2-chloro-6-(trichloromethyl)pyridine in the liquid phase at temperatures of about 160° C. to about 220° C. and in the presence of a metal halide catalyst, such as ferric chloride, are controlled by regulating the amount of hydrogen chloride present in the system, adding hydrogen chloride to obtain a mixture enriched in 3,6-dichloro-2-(trichloromethyl)pyridine or removing hydrogen chloride, usually by passing excess chlorine or an inert gas through the system, to obtain a mixture enriched in 3,5-dichloro-2-(trichloromethyl)pyridine.

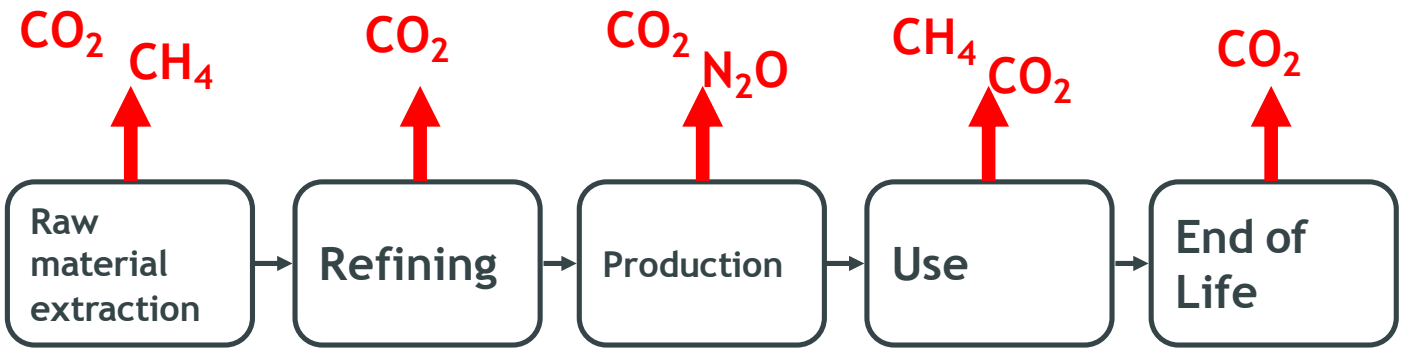
13 Claims, No Drawings

Life cycle assessment aids decisions

Life cycle assessment concepts



Impact Assessment

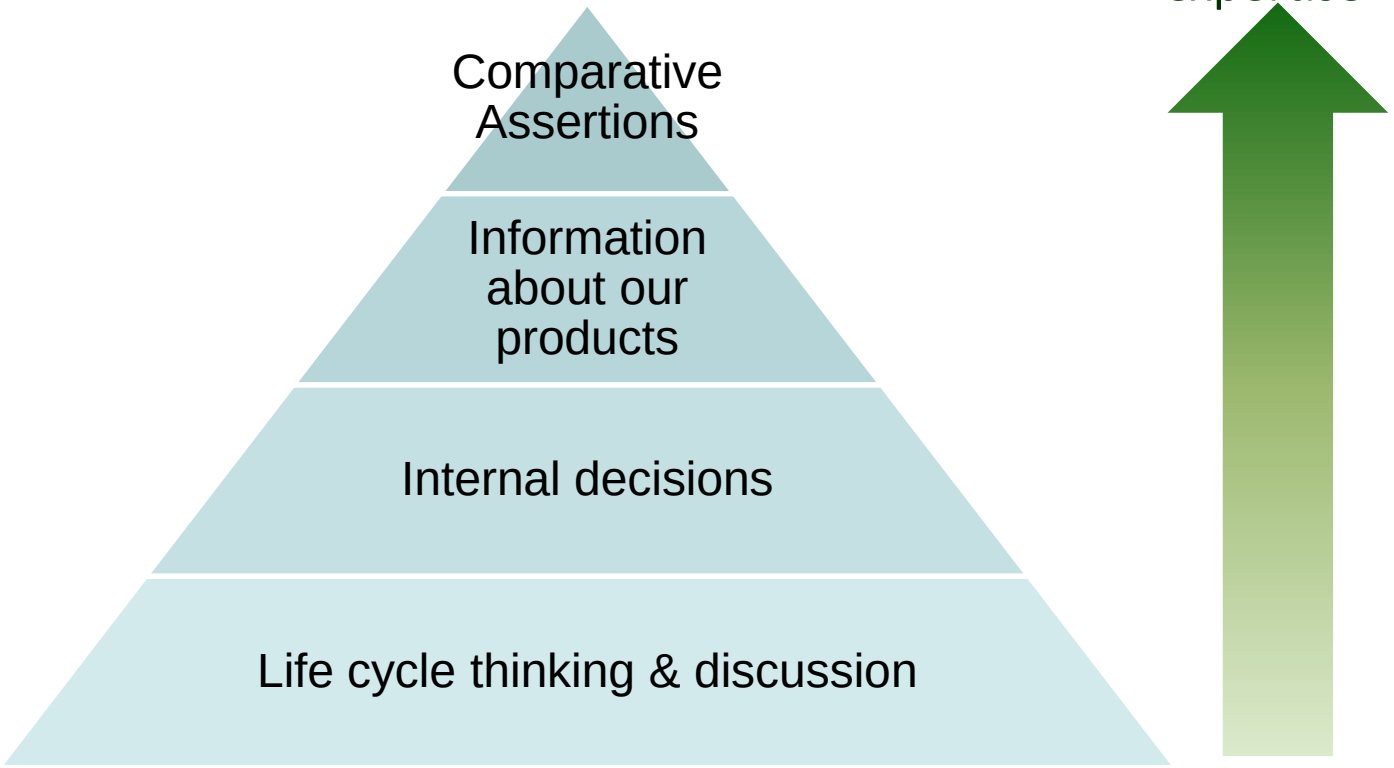


$$\text{Potential Environmental Impact} = \sum_{\substack{\text{all stages} \\ \text{all species}}} \text{Flow} \times \text{Characterization Factor}^*$$

*Such as:

- Global Warming Potential (*climate change, carbon footprint*)
- Acidification Potential (*acid rain*)
- Eutrophication Potential (*water pollution, anoxia, dead zone)*
- Photochemical Oxidant Creation Potential (*summer smog)*

The LCA pyramid



Balancing rigor & speed

What if we could make films with low-density core?

*not the actual product, but a good picture!

Quick LCA results for low-density cores

metric	Current technology	Foam core option 1	Foam core option 2
Global warming potential			
Ozone depletion potetial			
Photo-chemical oxidant creation potential			
acidification potential			
Freshwater eutro-phication potential			
Agricultural land occupation			
Water depletion			
Marine eutrophication			
Fossil depletion			

- *~1 day work*
- *~1 day for report*

What if we used non-fossil filler for polyethylene films?

Quick LCA results for PE fillers

metric	Current Technology	Inorganic filler	Organic filler 1	Organic filler 2
Global warming potential				
Ozone depletion potetial				
Photo-chemical oxidant creation potential				
acidification potential				
Freshwater eutro-phication potential				
Agricultural land occupation				
Water depletion				
Marine eutrophication				
Fossil depletion				

- *~1 day work*
- *~1 day for report*

Example: Sugarcane-based polyethyelene

Conventional Route

Petroleum-based

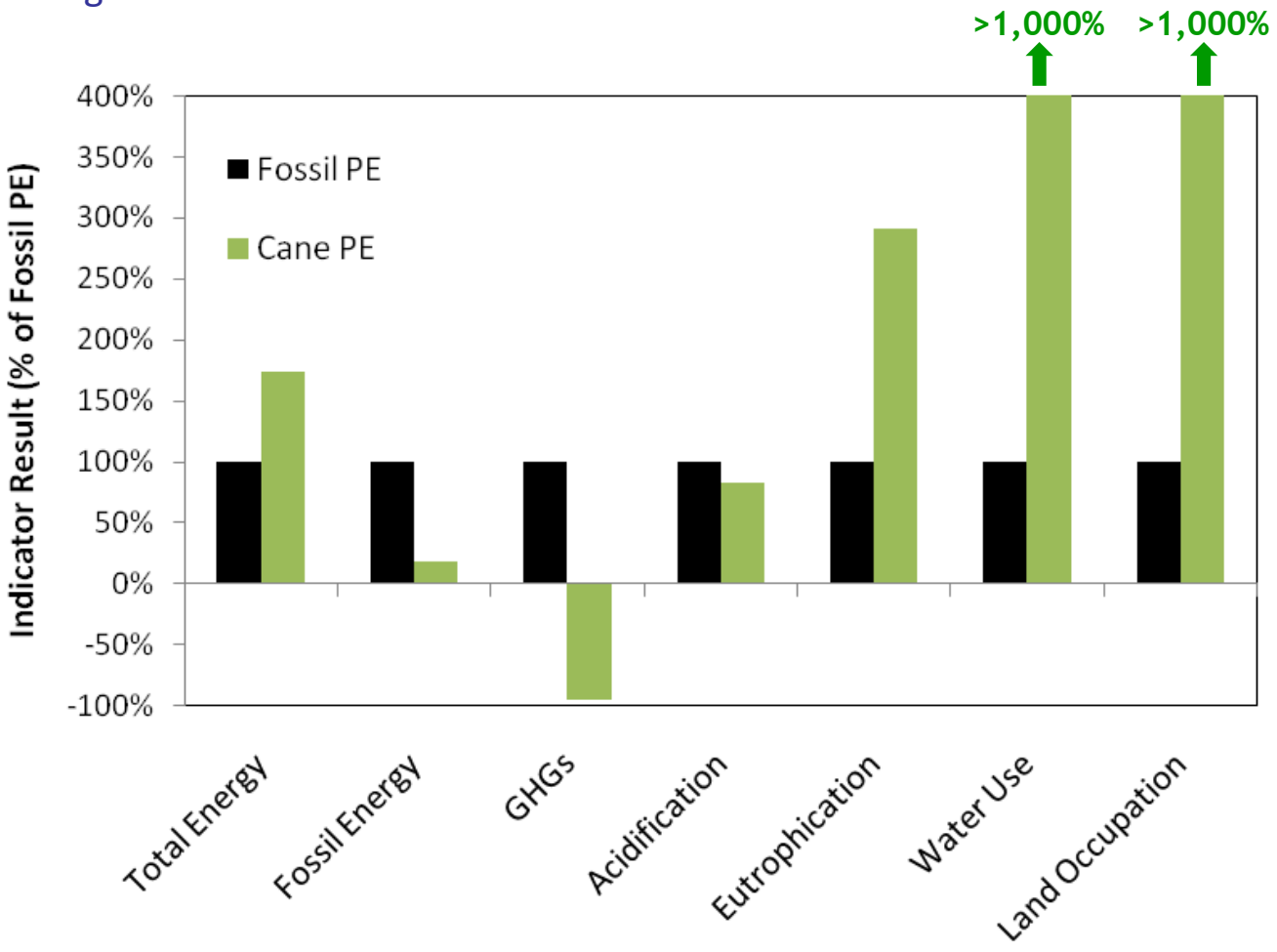
Biobased Route

Sugarcane-based

DOWLEX
polyethylene resins

Advantages & trade-offs of cane PE

Cradle-to-gate LCA results

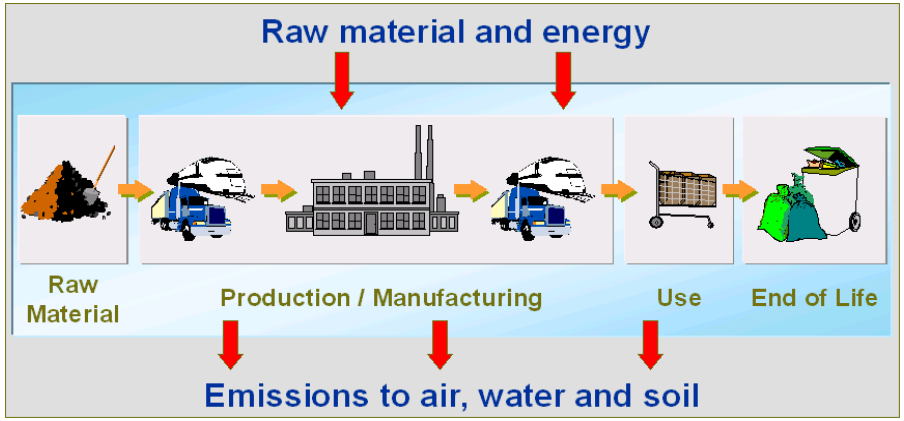


LCA results led to site-specific investigation of “high” metrics

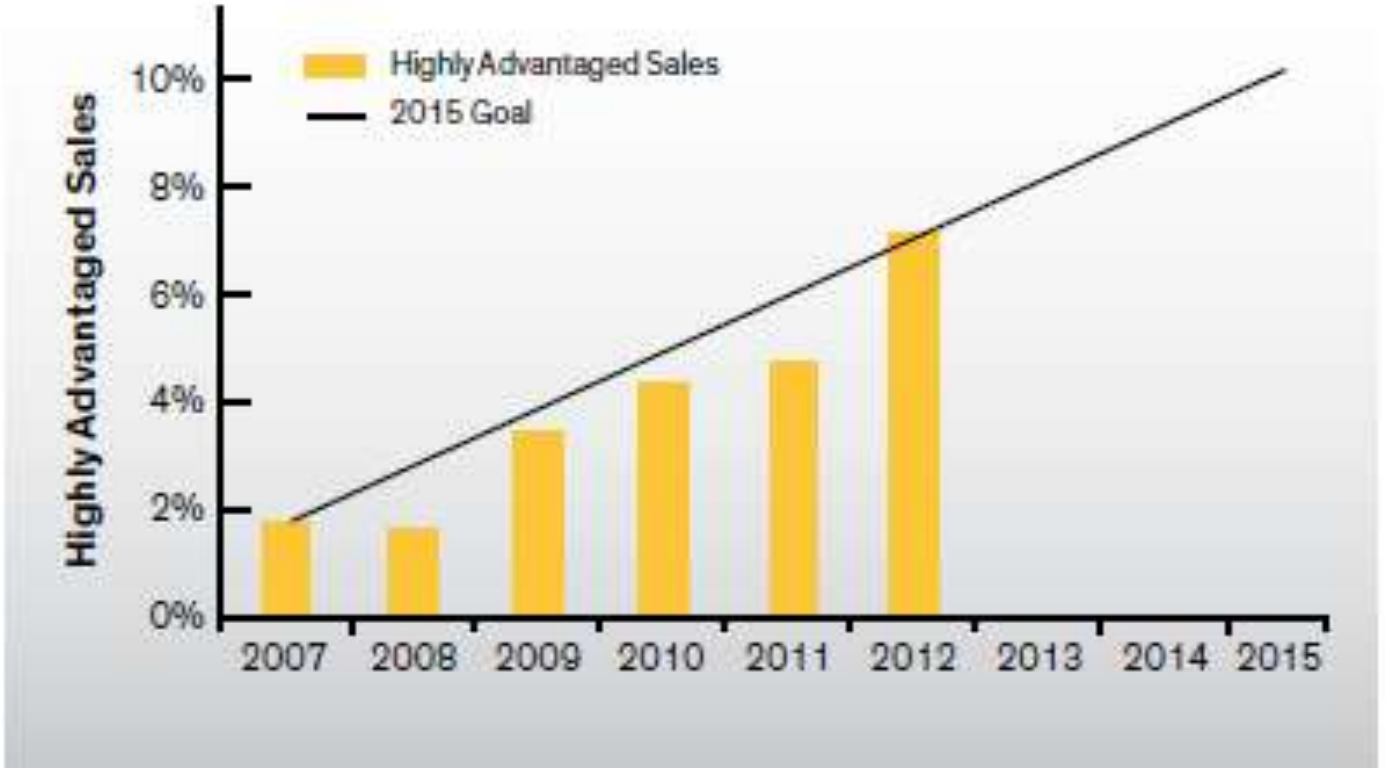
Sustainable Chemistry Index

FSC

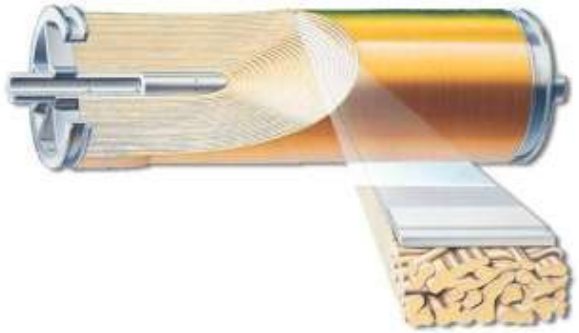
CERTIFIED SUSTAINABLE PALM OIL ™
RSPO



SCI defines “highly advantaged sales”



Innovative product examples



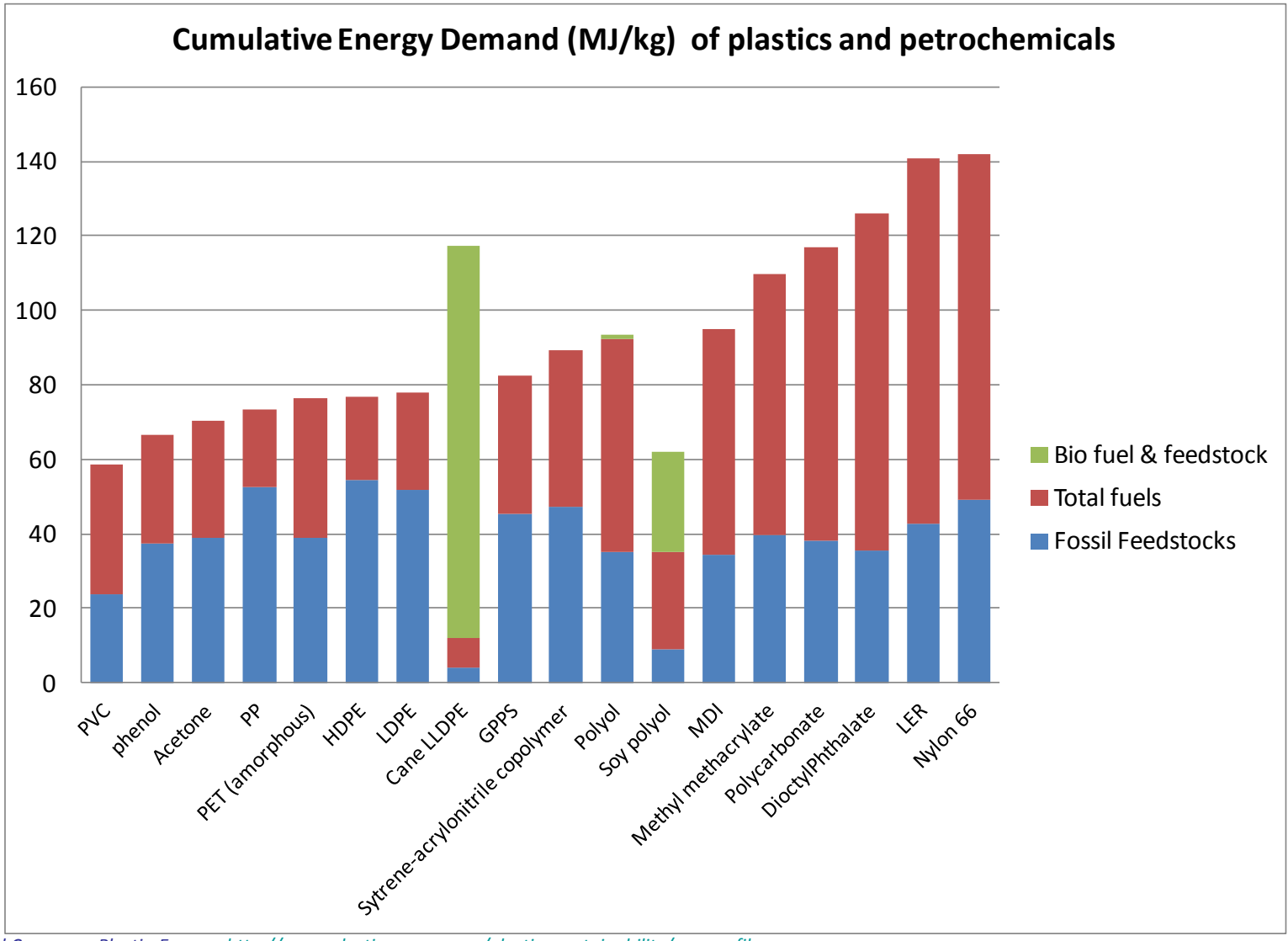
Summary

- Sustainability is essential
- Technology can affect impacts
- Drivers for more sustainable innovations:
  - Future vision
  - Individual awareness
  - Quantitative understanding for projects, products, businesses & the corporation

Thank you!

Details on innovation examples

Examples of *renewables* in LCA



Sources: The Dow Chemical Company; PlasticsEurope; http://www.plasticseurope.org/plastics-sustainability/eco-profiles.aspx

Omega-9 Healthy Oils

Description

Virtually free of trans fat and containing the lowest saturated fat content of any vegetable oil, and half the saturated fat of olive oil, Omega-9 Canola and Sunflower Oils can be used in numerous applications, including deep frying, sautéing, baking and in salad dressings.

Sustainability Profile

- Zero Trans Fat
- High in heart-healthy monounsaturated fat
- Lowest saturated fat of typical cooking oils and half the saturated fat of olive oil
- Since 2005 Omega-9 Oils have eliminated nearly 700 million pounds of trans fat and 300 million pounds of saturated fat from North American foods
- Studies show people prefer the taste of foods fried in Omega-9 Canola Oil over common oils

DOW™ POWERHOUSE™ ROOF SHINGLES

Description

Building integrated photovoltaic (BIPV) design combines roofing protection and power generation in one product.

Sustainability Profile

- Aesthetically pleasing and neighborhood-friendly, it's the best looking solar option available for asphalt rooftops
- Installed by a roofer along with standard asphalt roofing materials which eliminates additional steps and costs
- Interconnected system design allows for a single power connection
- Launched in October 2009, the POWERHOUSE™ Solar Shingle is now commercially available in select markets

TIME Magazine: "50 Best Inventions of 2009"

2012 AWARD WINNER
Gold Edison Award™
"Best New Product"

2010 AWARD WINNER
GLOBE Foundation
"Environmental Excellence in Emerging Technology"

Reverse Osmosis Membrane Technology

Description

FILMTEC™ reverse osmosis membranes produce freshwater through desalination and recycling wastewater around the globe.

Sustainability Profile

- Helps make desalination more energy-efficient and removes pollutants from wastewater
- Provide clean drinking water in water-stressed regions
- Decreases use of chemicals and GHG emissions
- Allows wastewater to be reused in industrial processes, agricultural and landscape irrigation, toilet flushing, gardening and ground water replenishment

2009
AWARD WINNER
ACS Heroes of Chemistry
"Impact on Society"

Polymeric Flame Retardant

Description

Dow's next-generation flame retardant is safer for human health and the environment compared to existing insulation material alternatives, without sacrificing performance or cost.

Sustainability Profile

- High-molecular-weight polymeric flame retardant
- Effective level of flame retardancy that's non-persistent, bioaccumulative or toxic
    - Specifically does not pose risk to marine environments
- Fire safety solution for EPS and XPS foams
- Enables insulation materials to meet increasing demands of global energy efficiency regulations
- Promotes global supply security and industry transition to a more sustainable flame retardant solutions

2012
AWARD WINNER:
Michigan Governor's
Green Chemiistry